INFANT FEEDING

By HELEN MARION WARFIELD
Graduate Children's Hospital, Boston, Supervisor of Wards

PROBABLY no advance which recent medicine has made has had a greater effect upon the sum total of human health than the new methods of infant feeding. Progress in this line has had a double impetus—one, the natural stimulation which research in any department of medical science is bound to give the whole subject; the other, that the number of mothers who, for various reasons, are unable to nurse their infants is constantly on the increase with a growing demand for substitute nourishment—and the necessity for knowledge is often the mother of its supply.

No methods are superior to nature's, and the form of artificial food which most closely simulates the natural article is obviously best adapted to the purpose. The most perfect substitute, therefore, is a wet-nurse whose own infant is of the same age as the child whose normal nourishment is denied it. This being difficult and in many cases impossible to provide, recourse is usually had to some other animal milk than the human.

We often hear milk spoken of as a "perfect food," but a food to merit such a title must conform to many tests. Among others it must not only contain the required elements of nutrition, but the constituents must be so combined as to furnish the proper nourishment. The nourishment which nature adapts to the requirements of a calf or goat or ass differs in its natural state in many ways from that which the digestion of the human infant demands.

All milk is composed of about eighty-eight per cent. of water witl a varying degree of fat, carbohydrate, proteid elements, and salts, according to its source. Human milk also varies greatly according to the period of lactation, growing weaker in solid constituents until by the end of the first year it no longer contains sufficient nourishment to meet the demands of the infant system. Analyses of human milk assay approximately four per cent. fat, seven per cent. sugar, 1.5 per cent proteid, one-tenth to two-tenths of one per cent. salts, and about eighty-eight per cent. of water. This, then, is to be our standard; from some other source we are to evolve a food of equivalent composition.

Various physicians have different preferences,—for ass's, mare's, or goat's milk,—based upon the ground that they are more closely allied to human milk, not necessarily in percentage, but in the character of the constituents. But these sources are open to the same objection as the

wet-nurse—*i.e.*, in the majority of cases they are out of the question from the expense and difficulty of attainment. Modified cow's milk is the almost universal substitute, and the milk to be most desired is mixed milk from a herd of healthy, hygienically cared for cows, composed chiefly of the Durham and Holstein breeds, with a few Jerseys in the group. Jersey milk alone is too rich in fat for most babies to digest, while the Durham and Holstein milk is rather deficient in it. The old idea of the desirability of the daily supply from one cow on the ground of its uniformity has been annihilated. Supply from a mixed herd under the same conditions is much more uniform, being less affected from day to day by individual indisposition or other change of conditions.

The approximate percentages of the solids of whole cow's milk are about four per cent. fat, four per cent. sugar, and four per cent. proteid. With the exception of fat the proportions are therefore quite different from our model, and it is evident that we cannot arrive at it by mere dilution, since the dilution of one factor must lower the other ingredients proportionately. Our standard can, however, be partially obtained by the dilution of the top instead of the whole milk.

The proportions of the solids of milk set to rise for eight hours are about:

10 per cent. fat, 4 per cent. sugar, 4 per cent. proteid in the upper third.
12 per cent. fat, 4 per cent. sugar, 3.8 per cent. proteid in the upper fourth.
16 per cent. fat, 4 per cent. sugar, 3.6 per cent. proteid in the upper sixth.

From the fact that the ratio of the fat increases according to the nearness of the top, it is, of course, necessary to remove the entire portion which contains the percentage whose dilution will assay the required fat and stir this thoroughly before using, in order that the fat percentage may be uniform throughout the mass. By the centrifugal separator used in laboratories and creameries the heavier constituents are more quickly and thoroughly precipitated, while the fat, being lighter, rises, and cream may be obtained having as high as sixty-five per cent. fat. Obviously we can only obtain the proportions we desire by the use of cream. For most purposes a gravity cream of ten per cent. fat will be sufficient, but if we desire a relatively low proteid we must use a cream of higher percentage.

A centrifugal cream of sixteen per cent. fat, containing four per cent. sugar and 3.6 per cent. proteid, has the advantage of giving a high fat with a proportionately very low proteid, and can therefore be used as a foundation of almost any modification that can be required. With this as our base we should need to use one part of cream to three parts of

water to obtain four per cent. fat in our mixture, which would therefore give us one per cent. sugar and .9 per cent. proteid. If, now, we are modifying to a 1.5 per cent. proteid, we must add some agent which contains proteid, but which shall be at the same time fatless. This agent we have in fat-free milk. The lower fourth of milk set eight hours is practically fatless, and a much larger proportion of milk whose cream has been removed by the centrifugal separator is without fat.

Now this milk contains the same proportion of sugar as whole milk and cream, and in adding the number of cubic centimetres or ounces required to bring the proteid constituents to the formula we are also adding sugar. Sugar being, however, the chief solid constituent of human milk, we shall still be short of the percentage required. This we increase by adding commercial sugar of milk. This form of sugar is exactly the same article as is already in solution in the milk. It is prepared from milk separated and evaporated and differs very materially from vegetable sugar. Its chief difference and advantage in infant feeding lies in the fact that it is the form of sugar which is least liable to undergo fermentation in the digestive tract.

Milk-sugar is usually measured in small sugar dippers and the amount necessary to add to the mixture is reckoned as so many measures of sugar, with the quantity contained in the cup as the unit of measurement. It is about equivalent to a tablespoonful and corresponds to a little more than half an ounce in weight.

The sugar is figured last for obvious reasons, but in preparing a modification it is the first ingredient which is put into the sterile pitcher or jar. To this is added the diluent, usually boiled water, hot or cold, in which it is thoroughly dissolved. The sugar is not very completely dissolved in the milk if added last. It dissolves most quickly and thoroughly in hot water, but this necessitates chilling before the addition of cream and milk to avoid that temperature half way between heat and cold which is one of the most favorable conditions for the growth of bacteria.

It is, of course, necessary to heat the milk to serve, but if the bottle containing the amount of the feeding is put into cold water and quickly brought to the temperature of the stomach, and given at once through a sterile nipple, the danger of influencing the growth of germs is very little.

The mineral matter of both cow's and human milk is composed of a small amount of lime, magnesium, calcium, chlorine, sulphur, potash, and phosphorus. At present no attempt is being made to modify these constituents, though the differences cannot by any means be disregarded, the reaction of the salts upon the other ingredients during digestion being distinctly in favor of human milk.

We have now, as far as percentages are concerned, obtained a creditable substitute for human milk. Nevertheless, there are still several points of difference which we have not considered. A very important one is the reaction. Milk from the breast or udder is neutral or faintly alkaline, but speedily becomes acid upon standing. To counteract this acidity it is necessary to use some alkaline agent. The best one for the purpose is lime-water, as its reaction upon the proteid has some effect upon the toughness of the curd. About six per cent. is usually enough to restore the mixture to neutrality, though lime-water up to twenty-five to fifty per cent. is sometimes given to aid digestion as a diluent or to counteract excessive acidity of the gastric juice.

Also, while milk freshly drawn is a sterile fluid, it furnishes one of the best media we have for the growth of germs; some forms which grow but sluggishly in bouillon, gelatine, or agar-agar thrive exuberantly in milk. It has also a remarkable power of absorbing odors. For these reasons milk should always be kept covered, in a cold place, and apart from other foods. Even with such precautions, however, it often seems unwise to introduce a fluid open to any suspicion into a baby's alimentary canal, and in cases of enteric disturbance milk is usually pasteurized or sterilized.

Pasteurization consists in quickly heating the milk to a temperature of 155° F., maintaining this heat for fifteen or twenty minutes, and immediately cooling again. At this temperature the greater part of the bacteria in the milk are destroyed and the character of the food is still unchanged. At any higher degree the digestibility of the milk is interfered with by the coagulation of the casein of the proteid.

The advantages of sterilization are also predominant over its disadvantages in cases of possibly infected milk supply, the necessity for keeping for several days, or in fermental or bacterial diseases of the enteric tract. A temperature of 212° F. maintained for twenty minutes will kill all germs, including the bacteria which act upon the sugar to form lactic acid, the cause of so-called "sour" milk. If kept tightly covered, this food will be found unchanged days or weeks later, especially if it is subjected in this interval to heat for three successive days.

To the advantages of sterilization, however, we have sacrificed the freshness of the food,—a characteristic of our model milk,—we have cooked part of the proteid into a tough coagulum difficult to digest, and we have changed the taste of the milk by caramelizing the sugar. Moreover, it is in the train of cooked and patent foods that scorbutus and rhachitis follow, and a sterilized diet is nowadays usually discontinued as soon as conditions warrant its omission.

The lime-water should be added to sterilized milk just before heating

to serve, as the albuminoids are more or less decomposed by boiling in an alkaline solution, and the taste of the milk is still further affected by the action of the lime upon the sugar in cooking.

We have yet another important comparison to make between the natural and our substitute food, namely, in the character of the constituents themselves. It is not enough that we should obtain a food of similar percentages and reaction; medical science now aims to provide a food of equivalent digestibility.

Now the fat of all milk is made up of minute globules, some one million five hundred thousand in each drop. Manifestly the fineness of this emulsion favors its digestibility, since the finer the division the less work will be put upon the digestive organs in its assimilation. The fat of human milk taxes the infant digestion less than cow's milk for the reason that these fat droplets are of smaller size and have thinner envelopes, and in prescribing a substitute milk it is therefore customary to order one whose fat is of slightly less percentage than that which the same baby would be fed from its mother's breast.

Although, as we have seen, we are able to reproduce exactly the carbohydrate of human milk, the proteid constituents present another difficulty, and one which is of great moment to a delicate infantile digestion.

The proteid of both milks is made up of two elements, lactalbumin and caseinogen. Milk upon entering the stomach is first acted upon by the rennin enzyme of the gastric juice, which coagulates the caseinogen into a tough, leathery mass. Lactalbumin escapes this extreme degree of coagulation, forming a loose, friable curd, readily acted upon by the next ferment of digestion.

Now the proteid of human milk is composed chiefly of this easily digested element, the proportion being about two-thirds lactalbumin to one-third caseinogen, as opposed to one-sixth lactalbumin and five-sixths caseinogen in cow's milk. This must also be taken into consideration in substituting a modified milk for a baby's natural supply, and a lower percentage of the proteid element given in order to avoid too great a tax upon the baby's power of digesting casein. In substituting for a human 4, 7, 1.5 the baby would probably be prescribed a modified 3, 6, 1. He stands a better chance of ultimately digesting a higher percentage of nourishment if started on a weak mixture and brought up to his point of tolerance than if his feeding is adjusted by a descending scale.

One of the most recent advances in infant feeding, however, relates to this matter of the proteid elements. By the use of whey the constituents can be so modified that they correspond very nearly to our

human sample. Whey is the exudate from clotted milk and contains its water, sugar, salts, and lactalbumin, the fat and caseinogen being coagulated in the curd. It is obtained by a partial artificial digestion of skim milk through the addition of some agent containing rennin—Shinn's liquid rennet, pancreatin extract, junket tablets, wine or fruit acids—to the slightly warmed milk, which is allowed to stand until set, the curd then broken up with a fork or spoon and strained through fine muslin. The fluid should then be heated to a temperature of 155° F. to destroy the rennin. The resulting whey should contain about four-fifths of the bulk of the milk.

Every ounce of whey in a twenty-ounce mixture will add five-one-hundredths of one per cent. lactalbumin to the proteid, and since whey contains the sugar of the milk, the sugar will be increased one-fourth of one per cent.

It is evident that in a high-percentage cream from which to obtain the fat desired, skim milk to add whatever casein may be lacking in the cream, whey to furnish the required amount of lactalbumin, and milk-sugar to provide whatever carbohydrate may still be wanting, we have sufficient material to very nearly approximate our model food; and if this is prepared from milk of trustworthy source, under conditions which are as far as possible aseptic, every ingredient carefully measured, the amount of each feeding poured into a sterile tube, stoppered with sterile cotton and kept ice-cold until time of using, then only heated to the temperature of the stomach and served at once through a sterile nipple, we have approximated—to the extent of our ability, at any rate—the relative composition, freshness, and freedom from germs of the maternal food.

This method, however, has its opposers on account of the separation and recombination which it necessitates. The objection is that so much handling is neither conducive to the sterility of the milk, nor do the elements recombine with the same readiness when once separated. There is a means of rendering the proteid more digestible which is certainly simpler than the whey modification. It is by the use of cereal water as a diluent. This does not increase the lactalbumin nor does it decrease the caseinogen, but it prevents by its mucilaginous qualities the formation of a dense clot, keeping it loose and flocculent and less resistant to further digestion. In these instances barley-water is the diluent chiefly used, both on account of its demulcent characteristics and its relatively small percentage of starch (about one per cent.). Oatmeal-water not only adds a certain amount of fat, but has a sometimes undesirable laxative effect for that reason. There are several different strengths of cereal waters in use as diluents by different physicians. A common proportion is two ounces of barley or oatmeal flour, made into a paste,

to one quart of boiling water; after boiling twenty minutes this is strained, enough boiled water added to replace that lost by evaporation, and cooled. In making cereal gruel for older babies who are being weaned, to whole milk twice the amount of flour is used, and for cereal jelly three times the amount.

Theoretically, however, this method is also open to objection. All cereals are chiefly starch, and one of the greatest claims that milk can make to being a perfect infant food is that, its carbohydrate being all sugar, it introduces no element which can hamper an infant digestion from its undeveloped power of assimilating starch.

Attempts have been made to overcome the objection of this foreign element of starch in the diluent by predigesting it before addition. There are several preparations on the market for this purpose. They contain a diastase ferment derived from malted cereal which converts starch into sugar—maltose or dextrin—according to the degree of heat used. Neither of these sugars, though differing from lactose, or milk-sugar, offer any great degree of resistance to an infant's digestive efforts, and there are cases of bacterial enteric infection in which the culture-growing property of milk contraindicates its use, and the child subsists very well upon predigested cereal water, animal broths, or some patent food until the bacterial activity has subsided.

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The stools and daily weight are the chief indices of the infant digestion and absorption. Normally they are smooth and yellow, partially formed, and of little odor. If the diet contains a greater quantity of fat than the system can absorb, they will be loose and slimy. Too high a sugar causes acid stools of sour odor and irritating to the skin. The green color of stools is usually caused by bacteria, which, though a foreign element, are not necessarily pathogenic.

In justice to food it must be said, however, that the appearance of the stools does not indicate disorders of digestion alone. So sympathetic is one part of a baby's system with every other part that the nervous disturbances of teething or excitement, temperature, etc., will also usually alter the character of the stools while the disturbance lasts.

Yet in spite of research and progress, the last word on infant feeding is yet to be spoken. Personal idiosyncrasy counts for no more anywhere than here. Each physician who undertakes a "feeding case" starts out to discover a new country or conquer a new world. The vagaries of infant digestion are inexplicable and endless, and a food prescription which is one baby's meat may be his twin brother's poison. A good infants' physician has not only a wide and unprejudiced knowledge of the subject, but infinite patience, adaptability, and resource, and the best infants'

nurse is the one to whom no slightest detail of hygiene, absolute cleanliness, regularity, or comfort is anything less than of the utmost importance. The balance often hangs by a thread, and the scale may be turned by an unsuitable nipple on the nursing-bottle.

A NEW CRANFORD: BEING A MORE OR LESS TRUE ACCOUNT OF AN EXPERIMENT

DEDICATED TO OUR DEAR J. B., WHO OF ALL OTHERS BEST UNDERSTANDS WHAT PROMPTED ITS UNDERTAKING

By ISABEL McISAAC.
Late Superintendent of the Illinois Training-School, Chicago

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II. WILLIAM THE CONQUEROR

Buying a horse is a serious undertaking for womenfolk who are entirely inexperienced, but Euphemia's best friend, Rachel, knew a man whose brother-in-law had a beast to sell which was highly recommended. The man Miss Rachel knew being a proper sort of person who could be depended upon, as far as any masculine being can be concerning horses, we bought Billy. Billy's former owner said he was "used to women, quite safe but playful," and Euphemia still contends that the man told the truth; but no dictionary I ever saw defines playfulness as a systematic determination to break people's necks, and if Billy's behavior is playful, for my part I prefer something less coquettish.

The first day Euphemia took him out she was to drive him over our own road, which was heavy with snow, while I got into my coat and rubbers. Fortunately, I happened to look out just in time to see the sleigh turn over and Euphemia and Billy disappear with great suddenness. As the road is on the side of a very steep bluff, I fully expected to find them in small pieces in the bottom of the ravine, but they were lying on the hillside in a hopeless tangle of snow, harness, cushions, robes, and kicking hoofs, and only after much shovelling, cutting of straps, and the most terrifying plunges did we get them right side up. At this point Euphemia decided to make Billy walk down the soft road without the sleigh while she walked behind, driving him; but his ideas were not hers, and after going very demurely half-a-dozen steps he spied the red barn on the top of the hill, and instead of retracing his steps over